JOURNAL
OF THE
WASHINGTON ACADEMY OF SCIENCES

VOL. 18 JUNE 19, 1928 No. 12

SPECTROSCOPY.—*Multiplets in the Co* II *spectrum.*[1] WILLIAM F. MEGGERS, Bureau of Standards.

A study of the absorption spectra of iron, cobalt, and nickel[2] as produced by condensed sparks between metallic electrodes under water revealed for each metal several hundred lines characterizing the neutral atoms and a much smaller number ascribed to ionized atoms. Extensive classifications of the lines from neutral atoms showed that practically all of the absorbed lines involved low-energy states of the respective atoms. A similar interpretation for the absorbed lines due to ionized atoms was indicated by Russell's[3] analysis of the Fe II spectrum, and the observations were useful in the cases of nickel and cobalt for detecting the first regularities among their spark lines. The Ni II spectrum has since been more fully analysed by Shenstone;[4] the purpose of the present note is to give some preliminary results for the Co II spectrum.

A portion of the spectrum (2150–5000 A) has been remeasured, relative intensities have been estimated on an expanded scale and several classes of spark lines have been recognized by comparison of their behavior in the spark and arc. Thus certain groups of lines in the spark spectrum appear with almost equal intensity in the arc spectrum while others are much weaker in the second case, and still others show very weak or not at all in the arc but strong and usually more or less diffuse and unsymmetrical in the spark. The first class includes all the lines observed in the absorption experiments referred

[1] Publication approved by the Director of the Bureau of Standards of the U. S. Department of Commerce. Received May 8, 1928.

[2] MEGGERS and WALTERS. Sci. Pap. Bur. Stand. (551) **22**: 205. 1927.

[3] RUSSELL. Astrophys. Journ. **64**: 194. 1926.

[4] SHENSTONE. Phys. Rev. **30**: 255. 1927.

to above, and some of them have been observed partially self-reversed in the spark in air. Such a group lies between the wave length limits 2249 A and 2449 A; it has been arranged as a trio of multiplets $^5F'$-$^5(D', F, G')$. This is the most prominent feature of the entire spectrum interval thus far examined. A somewhat weaker group of lines extending from 2192 A to 2339 A, overlaps the other group: it has been arranged on the basis of line intensities as a second trio of multiplets, $^3D$ - $^3(P, D', F)$. The triplet-D term was recognized in a strong group of lines between 3353 A and 3621 A constituting the intersystem combinations $^3D$ - $^5(D', F)$. These three sets of combinations are presented in Table 1. Term symbols and relative term values appear at the top and left margin, the term values being relative to $^5F_5' = 0.0$. Each combination of levels is represented by the observed wave length and estimated intensity (in parenthesis) of the spectrum line, and by the wave number in vacuum. The interval ratios for levels of the $^5F'$ term are 254.1:389.3:531.9:678.5 = 1.9:2.9:3.9:5.0 while the theoretical ratios are 2:3:4:5. When the interval ratios are in such good agreement with the theoretical values it is a good indication that the term either represents the normal state or a very low metastable one.

Although neutral cobalt is fairly strongly represented by absorption lines in the solar spectrum no spectroscopic evidence for the presence of ionized cobalt in the solar atmosphere has been put forward. In this connection it is interesting to note that the intersystem combinations $^3D$ - $^5(D', F)$ between 3353 A and 3621 A appear to be the only set of strong Co II lines lying within the range of solar spectrum transmitted by the earth's atmosphere, practically all of the other strong lines being less than 2900 A in wave length. The presence or absence of ionized cobalt in the solar spectrum must therefore rest with this group of spectral lines. Comparison of the wave lengths and intensities of these lines with absorption lines in Rowland's *Preliminary table of solar spectrum wave lengths*, is shown in Table 2. My wave length data for the Co II lines appear in the second column and Rowland's values for solar lines (the original and the reduced value on the International Ångstrom scale) are given in the fourth column. My intensity estimates are in the third column and Rowland's in the fifth. The last column indicates special reasons for regarding the coincidence of five of the Co II lines as doubtful. For the remaining nine lines the mean difference between my values and the corrected Rowland wave lengths is $\pm 0.02$ A, which is the average probable

TABLE 1.—MULTIPLETS IN THE Co II SPECTRUM

| | $^5F_5'$ 0.0 | $^5F_4'$ 678.5 | $^5F_3'$ 1210.4 | $^5F_2'$ 1599.7 | $^5F_1'$ 1854.2 |
|---|---|---|---|---|---|
| $^5D_4'$ 42028.3 | 2378.62(100) 42028.3 | 2417.66(40) 41349.7 | 2449.15(10) 40818.1 | | |
| $^5D_3'$ 42621.7 | | 2383.45(80) 41943.2 | 2414.06(40) 41411.4 | 2436.98(10) 41021.9 | |
| $^5D_2'$ 43102.3 | | | 2386.37(50) 41891.9 | 2408.76(25) 41502.5 | 2423.61(10) 41248.2 |
| $^5D_1'$ 43436.0 | | | | 2389.54(40) 41836.3 | 2404.17(20) 41581.7 |
| $^5D_0'$ 43739.6 | | | | | 2386.74(25) 41885.4 |
| $^5F_5$ 41847.4 | 2388.90(100) 41847.5 | 2428.29(10) 41168.7 | | | |
| $^5F_4$ 42970.4 | 2326.48(25) 42970.2 | 2363.79(80) 42292.0 | 2393.91(10) 41759.9 | | |
| $^5F_3$ 43688.8 | | 2324.30(40) 43010.5 | 2353.43(60) 42478.2 | 2375.19(15) 42089.0 | |
| $^5F_2$ 44187.0 | | | 2326.12(30) 43976.8 | 2347.40(30) 42587.3 | 2361.52(10) 42332.7 |
| $^5F_1$ 44498.5 | | | | 2330.35(30) 42898.8 | 2344.26(25) 42644.3 |
| $^5G_6'$ 43728.0 | 2286.16(100) 43728.0 | | | | |
| $^5G_5'$ 43995.6 | 2272.26(8) 43995.4 | 2307.84(75) 43317.2 | | | |
| $^5G_4'$ 44457.1 | 2248.66(2) 44457.1 | 2283.52(15) 43778.5 | 2311.60(50) 43246.8 | | |
| $^5G_3'$ 44800.6 | | 2265.74(3) 44122.0 | 2293.39(20) 43590.1 | 2314.04(40) 43201.2 | |
| $^5G_2'$ 45038.0 | | | 2280.96(4) 43827.6 | 2301.40(15) 43438.4 | 2314.97(30) 43183.8 |

TABLE 1—*Continued*

| | $^3D_3$ 14421.2 | $^3D_2$ 14681.2 | $^3D_1$ 14988.5 |
|---|---|---|---|
| $^3P_2$ 59994.4 | 2193.58(15) 45573.3 | 2206.18(12) 45313.0 | 2221.22(5) 45006.2 |
| $^3P_1$ 60315.4 | | 2190.65(10) 45634.2 | 2205.50(5) 45327.0 |
| $^3P_0$ 60420.6 | | | 2200.40(6) 45432.1 |
| $^3D_3'$ 57890.8 | 2299.76(20) 43469.4 | 2313.58(8) 43209.7 | |
| $^3D_2'$ 57910.2 | 2298.73(8) 43488.9 | 2312.54(10) 43229.2 | 2329.11(10) 42921.7 |
| $^3D_1'$ 57734.2 | | 2322.01(5) 43052.9 | 2338.69(6) 42745.9 |
| $^3F_4$ 58037.8 | 2291.98(40) 43616.6 | | |
| $^3F_3$ 59208.8 | 2232.05(15) 44787.9 | 2245.11(30) 44527.4 | |
| $^3F_2$ 60017.2 | 2192.48(10) 45596.1 | 2205.06(3) 45336.0 | 2220.11(15) 45028.8 |
| $^5D_4'$ 42028.3 | 3621.22(100) 27607.2 | | |
| $^5D_3'$ 42621.7 | 3545.03(25) 28200.5 | 3578.03(30) 27940.4 | |
| $^5D_2'$ 43102.3 | ? 28681.0 | 3517.48(10) 28421.3 | 3555.93(10) 28114.0 |
| $^5D_1'$ 43436.0 | | ? 28754.8 | 3514.21(5) 28447.8 |
| $^5D_0'$ 43739.6 | | | ? 28751.1 |

TABLE 1—*Concluded*

| | $^5D_3$ 14421.2 | $^5D_2$ 14681.2 | $^5D_1$ 14988.5 |
|---|---|---|---|
| $^5F_5$ 41847.4 | | | |
| $^5F_4$ 42970.4 | 3501.73(200) 28549.2 | | |
| $^5F_3$ 43688.8 | 3415.78(75) 29267.5 | 3446.40(100) 29007.5 | |
| $^5F_2$ 44187.0 | 3358.59(10) 29765.9 | 3388.2(50?) 29505.8 | 3423.84(75) 29198.6 |
| $^5F_1$ 44498.5 | | 3352.80(30) 29817.3 | 3387.72(60) 29509.9 |

TABLE 2.—Co II Lines in the Solar Spectrum

| *Terms* | λ *I.A.* | *Intensity* | *Row.* λ *I.A.* | *Intensity* | *Notes* |
|---|---|---|---|---|---|
| $^5D_3$-$^5F_1$ | 3352.80 | 30 | 3352.908 | 000 | |
| | | | 0.771 | | |
| $^5D_2$-$^5F_2$ | 3358.59 | 10 | 58.771 | 00 | Doubtful |
| | | | 0.634 | | |
| $^5D_1$-$^5F_1$ | 3387.72 | 60 | 87.854 | 00 | |
| | | | 0.715 | | |
| $^5D_2$-$^5F_2$ | 3388.2 | 50 ? | 88.311 | 3 | Co I coincident |
| | | | 0.172 | | |
| $^5D_3$-$^5F_3$ | 3415.78 | 75 | 15.922 | 00 N | |
| | | | 0.782 | | |
| $^5D_1$-$^5F_2$ | 3423.84 | 75 | 23.972 | 0 N | |
| | | | 0.832 | | |
| $^5D_2$-$^5F_3$ | 3446.40 | 100 | 46.536 | 1 Nd? | Double in sun? |
| | | | 0.395 | | |
| $^5D_3$-$^5F_4$ | 3501.73 | 200 | 01.841 | 0 | |
| | | | 0.700 | | |
| $^5D_1$-$^5D_1'$ | 3514.21 | 5 | 14.382 | 0000 N | |
| | | | 0.240 | | |
| $^5D_2$-$^5D_2'$ | 3517.48 | 10 | 17.653 | 000 N | |
| | | | 0.511 | | |
| $^5D_3$-$^5D_3'$ | 3545.03 | 25 | 45.194 | 0000 | |
| | | | 0.053 | | |
| $^5D_1$-$^5D_2'$ | 3555.93 | 10 | 56.088 | 000 Nd? | Double in sun? |
| | | | 5.947 | | |
| $^5D_2$-$^5D_3'$ | 3578.03 | 30 | 78.138 | 0000 | |
| | | | 7.997 | | |
| $^5D_3$-$^5D_4'$ | 3621.22 | 100 | 21.340 | 2 | Masked |
| | | | 0.200 | | |

error of my determinations. The systematic difference for the same nine lines is only +0.002 A, and the intensities are roughly parallel. In other words, the lines are coincident and the presence of ionized cobalt atoms in the reversing layer of the sun is thus established.

It is noticed that the intensities of these Co II lines are very low in the sun, but it should be remembered that the lines in question involve excited states of the ionized cobalt atoms. The lines involving lower metastable states or the normal state should be considerably stronger in the solar spectrum but unfortunately these are all in the ultra-violet which is shut off by the earth's atmosphere. The strong lines of the $^5F' - {}^5(D', F, G')$ multiplets which were absorbed in the under-water spark are also assumed to end with a metastable state. This quintet F′ term is ascribed to the electron configuration $s\ d^7$ to which the metastable $^3D$ probably also belongs, but the true normal state is thought to be a triplet-F′ term from the configuration $d^8$. According to the method which Laporte[5] outlined for predicting the relative positions of such terms the low $^3F'$ $(d^8)$ term is expected to lie about 3500 $cm^{-1}$ lower than $^5F'$ $(s\ d^7)$ in the energy diagram of the $Co^+$ atom. This term has not yet been found but before its existence can be denied the spectrum must be more carefully studied in the ultra violet between 1800 A and 2200 A. However, Shenstone's[6] failure to find similar predicted low terms in the Ni II and Cu II spectra makes it appear probable that the explanation required for the apparent absence or low intensity of certain expected combinations will apply also to the Co II spectrum.

*Note added in proof.*—Lang (Phys. Rev. **31**: 773. 1928) has recently identified the lowest terms in the Ni II and Cu II spectra from wave length measurements in the ultra violet below 1900 A.

PHYSICAL CHEMISTRY.—*The diameter of the $CH_2$ chain in aliphatic acids.*[1] CHARLES SNOWDEN PIGGOT, Geophysical Laboratory, Carnegie Institution of Washington.

This paper gives a brief account of some of the earlier measurements in this particular field of investigation. They were made in the spring of 1923 at the laboratory of Sir William Bragg, at University College, London, and were part of a more comprehensive investigation

[5] LAPORTE. Zeitschr. Phys. **39**: 127. 1926.
[6] SHENSTONE. Phys. Rev. **30**: 264. 1927.
[1] Received May 2, 1928.

being carried out by Dr. Alexander Müller, to whom acknowledgment is hereby made for guidance and assistance in the work. Their earlier publication was delayed by the pressure of other duties.

When ordinary paraffin wax was exposed to a beam of X-rays, in a suitable apparatus, it gave lines similar to those produced by substances generally recognized as crystalline. This was rather an unexpected result, since paraffin wax had been regarded by many as an excellent example of an "amorphous" substance. This observation, however, indicated that it was either actually crystalline in the ordinary sense, or else possessed regularly recurring units which had the property of reflecting X-rays in a manner analogous to that of a substance possessing a recognized crystalline structure. It raised the question whether or not there might be crystalline compounds in paraffin wax which were similar to the higher aliphatic acids. These considerations led to an X-ray investigation of these substances.

Preliminary experiments showed that paraffin wax and stearic acid gave very similar lines on the photographic plate, and, furthermore, that there were two principal lines, of the first order, which seemed to be identical in the two substances.

Since paraffin wax must consist of a large number of chemical compounds, the above observation would indicate that some fundamental unit must be common to them all and have at least one dimension the same, or nearly the same, in each. Also that this dimension is the same, or nearly the same, in stearic acid.

In an homologous series such as must exist in paraffin wax, or such as is the series of aliphatic acids, the length of the molecules must obviously vary with the number of carbon atoms in the chain. This variation in length should reveal itself by varying distances between similar lines on the X-ray plate. Paraffin wax gave the two principal lines mentioned above, and also a great many other lines, some of which were extremely indistinct. The lines of varying distances might correspond to the varying lengths of different molecules and the apparently fixed lines to the cross-sectional dimension of their chains.

The above is briefly the sequence of reasoning, based on the first unexpected results obtained from exposing paraffin wax to a beam of X-rays.

The conclusion was reasonably obvious that a great number of organic compounds had one dimension in common, capable of influencing X-rays; also, that this dimension was most likely the cross-section of the aliphatic carbon chain; and that this same dimension, or one very close to it, occurred in stearic acid.

The suggestion was therefore obvious to measure this dimension in a number of pure aliphatic organic compounds. The aliphatic acids, because they could be crystallized, and so obtained in a state of great purity, were selected.

A further consideration which influenced their selection was the speculation regarding the possible influence of the -COOH, or carboxyl group which is attached to one end of the chain, whether or not this heavy group would influence the close packing and thereby the diameter of the chain. If it should, then its influence would probably be greater in the short chain molecules than in the long chain ones.

## EXPERIMENTAL

Since the equipment available did not permit of studying the acids which are liquid at ordinary temperatures (formic, acetic, etc.)[2] there was prepared[3] a number of the higher acids which are solids at ordinary temperatures. These were: pentadecylic, $C_{14}H_{29}COOH$; palmitic, $C_{15}H_{31}COOH$; stearic, $C_{17}H_{35}COOH$; and behenic, $C_{21}H_{43}COOH$ acids and they were recrystallized to a high degree of purity. They were studied by the "powder method" using copper rays. The results are tabulated below.

TABLE 1

| *Name of acid* | *Formula* | *Distance between lines* | *d in Ångstrom units* |
|---|---|---|---|
| Pentadecylic | $C_{14}H_{29}COOH$ | 3.898 | 4.26 |
| Palmitic | $C_{15}H_{31}COOH$ | 3.931 | 4.22 |
| Stearic | $C_{17}H_{35}COOH$ | 3.930 | 4.22 |
| Behenic | $C_{21}H_{43}COOH$ | 3.943 | 4.24 |
| Average | | | 4.235 |

## CONCLUSION

It is apparent that, within the limits of experimental error, the short dimension of all the acids studied is the same, i.e., $4.235 \times 10^{-8}$ cm. This would indicate that the chains of all the aliphatic acids have the same diameter. Apparently this diameter of the chain, which is really a measure of the close-packing[4] of the atoms making up the

[2] Apparatus enabling the sample to be cooled by liquid air is now in process of development.

[3] By Mr. N. K. ADAM, of London.

[4] See ALEX. MÜLLER and G. SHEARER. Trans. Chem. Soc. **123**: 3160. 1923.

chain, is not influenced by the carboxyl group. However, the shortest chain here investigated was comparatively long, possibly too long to be influenced by the carboxyl group, and it may be that the difference between fourteen and twenty-one carbon atoms is not sufficient to reveal any influence.

The indications are that all organic $CH_2$ chains are of the same diameter and that this is about 4.235 Å.

BOTANY.—*Studies of Venezuelan Bignoniaceae.—III. New species of the genus* Arrabidaea.[1] H. PITTIER, Caracas, Venezuela.

The study of the materials of the genus *Arrabidaea* collected in Venezuela by the author and his coworkers has resulted in almost doubling the number of species known in that country. As before, the author is indebted to Mr. T. A. Sprague of the Royal Gardens at Kew for the preliminary examination of the specimens and for many useful indications. Besides, this well known authority on the Bignoniaceae has described recently under the name of *Arrabidaea calodyctios*, one of our most interesting discoveries in the family. The best thanks are here extended to him.

1. ARRABIDAEA P. DC., Rev. Bign. 10. 1838 (ex parte)

CLAVIS SPECIERUM VENEZUELENSIUM USQUE ADHUC COGNITARUM

Ovula pro loculo 4-seriatim affixa; folia nonnulla saltem biternata, plerumque ternata; foliola plus minusve oblonga, breviter obtuso-acuminata, mucronulata, glaberrima; corolla extus subtomentosa; ovarium lepidotum (Sect. 1. PARACARPAEA) **1. A. inaequalis**

Ovula pro loculo biseriatim affixa

Ovula pro loculo 6–8; flores parvi; paniculae multiflores (Sect. 2. MICROCARPAEA) **2. A. carabobensis**

Ovula pro loculo plura vel plurima; flores pro rata generis magnis; capsula magna; calyx pro rata brevis, campanulatus, raro breviter tubulosus vulgo truncatus vel denticulatus (Sect. 3. MACROCARPAEA)

Folia stirpium adultarum praeter lepides probabiliter ubique etiamsi interdum parcissime obvias glabra i.e., pilis simplicibus destituta (Ser. 1. *Glabrae*)

Inflorescentia praecox; folia 3-foliolata; calyx bilabiatus; ovarium puberulum **3. A. acuminata**

Inflorescentia coaetana, paniculata, terminalis, amplia; foliola concolora

Folia simplicia (?) vel raro binata rarissime ternata, coriacea **4. A. platyphylla**

[1] *Studies of Venezuelan Bignoniaceae.*—II appeared in this JOURNAL 18: 170–172. 1928. Received May 2, 1928.

Folia ternata vel conjugata cirrho simplici clausa
Calyx subturbinatus, herbaceus, truncato vel minute denticulato, 9–10 mm. longus, corolla 3.5 cm. longa 5. **A. corymbifera**
Calyx truncato-campanulatus, integerrimus vel denticulatus, subtomentosus
Foliola obtusiuscula vel obtuse acuminata, sicca castaneo-viridia vel obscure ferruginea 6. **A. florida**
Foliola lata, obtusa vel plus minusve acuminata, sicca nigra vel purpurea; flores color rubro abundantes
Corolla 3.5–3.7 cm. longa; foliola plus minusve acuminata, venis primariis vulgo 5–6 7. **A. Chica**
Corolla 1.4–1.8 cm. longa; foliola lata, obtusa, venis primariis vulgo 6–7 8. **A. larensis**
Folia stirpium adultarum praeter lepides pilos simplices vel raro ramosos gerentia, ulteriores interdum ope microscopii tantum conspicui (Ser. 2. *Indutae*)
Foliola concolora (nec colore nec textura nec indumento discolora (Subser. 1. *Concolores*)
Rami novelli pilis divaricatis instructi; folia supra opaca, rigida, herbacea; calyx 4–5 mm. longus; corolla 4–4.5 cm. longa; ovula pro loculo 16–18 9. **A. guaricensis**
Rami novelli pilis appresis haud divaricatis induti; ovula pro loculo 20
Foliola apice rotundata supra glaberrima, subtus in axillis venarum conspicue pilosula, demum glaberrima; calyx 7–9 mm. longus; capsula parce lepidota, 1.8–2 cm. lata 10. **A. ovalifolia**
Foliola supra subtusque plus minusve tomentosa
Foliola apice acuminata, olivaceo nigra, subtus dense et molliter induta; calyx 4 mm. longus; corolla 4–4.2 cm. longa; capsula dense mollissimeque tomentosa 1 cm.l ata 11. **A. mollissima**
Foliola apice obtusa, cinerea vel ferruginea; calyx 8 mm. longus; corolla 4.5–5 cm. longa; capsula puberula vel glabrata, 1.2–1.7 cm. lata 12. **A. rotundata**
Foliola discolora, subtus indumento interdum minuto vel brevissimo non raro canescenti-tomentella (Subser. 2. *Discolores*)
Ovula pro loculo 10–16
Folia summa saltem simplicia parva; foliola supra minutissime lepidota, sicca atro-purpurea, subtus tomentella, incana vel subviolacea; corolla circa 1.6 cm. longa 13. **A. carichanensis**
Folia omnia ternata vel conjugata
Foliola utrinque ovali-rotundata, apice saepe emarginata, supra glabrata, venis subtus in axillis barbata, demum puberula vel glabrata; corolla 3.7–3.8 mm. longa 14. **A. Spraguei**
Foliola ovalia vel elliptico-oblonga, acutata vel acuminata, supra glabra, subtus canescentia; corolla 3.2 cm. longa 15. **A. barquisimetensis**
Ovula pro loculo 18–22
Folia subtus obsolete reticulata, late ovata, supra nitentia in sicco nigrescentia, subtus minute sericea, plus minusve roseo-rubescentia 16. **A. calodyctios**
Foliola subtus conspicuiter reticulata
Foliola basi plerumque leviter emarginata
Corolla 5.5 cm. longa; foliola supra costa venaeque exceptis glabra subtus parce pilosula 17. **A. lenticellosa**

Corolla 2.7–3 cm. longa; foliola supra submollia, subtus utrinque tomentella 18. **A. Sieberi**

Foliola basi rotundata vel sub-truncata, haud emarginata, supra glaberrima

Foliola supra in sicco nigrescentia, subtus canescentia, minute sericea; corolla 2.5 cm. longa; ovarium muricatulum 19. **A. zuliaensis**

Foliola supra in sicco plus minusve cupreocolorata, subtus in nervis nervulisque crispulo-hirtella demum glaberrima; corolla 2.2–2.4 cm. longa; ovarium lepidotum 20. **A. cuprea**

1. ARRABIDAEA INAEQUALIS (P. DC.) Baill. Hist. Pl. 10: 28. 1891.
AMAZONAS TERRITORY (BRAZIL): Ríos Cassiquiare, Vasiva y Pacimoni (*Spruce* 3272). The type from Dutch Guiana.

2. **Arrabidaea carabobensis** Pittier, sp. nov.

Frutex scandens, ramulis parce verruculosis, petiolis, petiolulis, rhachide inflorescentiarumque minute et dense tomentello-pubescentibus; foliis discoloribus, ternatis conjugatisve cirrho simplici clausis, modice petiolatis, petiolo tereto, supra applanato, foliolis (in specimine utrinque conjugatis) submembranaceis, petiolulis teretibus, laminis ovatis vel ovato-lanceolatis basi rotundatis, plerumque complicatis, apicem versus attenuatis, subacutis vel breviter acuteque acuminatis, marginibus leviter revolutis, supra minute pilosulis costa venisque inconspicuis impressis, subtus canescentibus dense tomentellis, costa venisque primariis 7–8 prominentibus venulis prominulis; cirrho plus minusve fulvovel cano-pubescente; paniculis floribundis, elongatis, terminalibus, ramis inferioribus e foliis summis axillaribus; bracteis bracteolisque ovatis ovato-oblongisve, obtusis; calyce pariter cano-tomentello, tubuliformi, minute penicillo-denticulato, purpurascente; corolla infundibulitubulosa, lobis late ovatis, acuminatis, subaequalibus, extus puberula vel minutissime pubescente, intus prope insertionem staminum villosa, lobulis puberulis; staminibus inclusis, glabris, thecis antherarum divergentibus, connectivo apice inconspicuo; disco breve, cupulato; ovario dense lepidoto, ovula pro loculo 6–8, biseriatis; stylo glabro; stigma bilobulato, lobulis lanceolatis, acutis; capsula deest.

Petiolus 1.8–2.4 cm. longus; petioluli 1–1.5 cm. longi; laminae 4.5–9.5 cm. longae, 2.5–4 cm. latae. Paniculae 15–30 cm. longae. Pedicelli 1.3 mm. longi. Calyx 3–3.5 mm. longus. Corolla 8–10 mm. longa. lobulis circa 2.5 mm. longis, 2.5–3.5 mm. latis. Stamina circa 2 mm. supra basin aequialte insidentia, 3.2–4 mm. longa; staminodium 1.5 mm. longum. Discus 0.6–0.7 mm. altus. Ovarium 1.7 mm. longum; stylus 6 mm. longus.

CARABOBO: Hacienda de Cura near San Joaquín, in bushes, flowers July 8, 1919 (*Pittier* 7915, type).

The only species of section *Microcarpaea* met with in Venezuela up to the present, it is evidently related to *Arrabidae Agnus-castus* P. D.C. but differs in the indument of the flowers, the shape of the corolla lobes, the hairy insertion of the stamens, the connective equalling the parallel thecae of the anthers, the ovules twice more numerous in each cell, etc.

3. ARRABIDAEA ACUMINATA (Johnston) Urban, Rep. Nov. Sp. Fedde **14**: 306. 1916.

ISLA MARGARITA: El Valle (*Johnston* 345, type).

4. ARRABIDAEA PLATYPHYLLA (Cham.) Bur. & K. Schum. in Mart Fl. Bras. $8^2$: 38. 1896.

PORTUGUESA: Guanare, Calvario hill (*Pittier* 12048). The type from Brasil.

5. ARRABIDAEA CORYMBIFERA (Vahl) Bur. in Engl. & Prantl., Pflanzenfam. $4^{ab}$: 213. 1895.

LARA: Vicinity of Barquisimeto (*J. Saer d' Héguert* 252). The type from State of Rio Grande, Brazil.

6. ARRABIDAEA FLORIDA DC. Prodr. **9**: 184. 1845.

FEDERAL DISTRICT: San Andrés de Caruao (*Pittier* 11937). Type from Japura Valley, Río Negro basin, Brazil.

7. ARRABIDAEA CHICA (Humb. & Bonpl.) Verlot, Rev. Hortic. **1864**: 154. 1864.

Margins of the Orinoco and Casiquiare rivers near Maypures, Esmeralda and Mandavaca (*Humboldt & Bonpland*, type); Maypures, on the Orinoco margin (*Spruce* 3618, var. *thyrsoidea*).

### 8. Arrabidaea larensis Pittier, sp. nov.

Frutex scandens, ramulis verruculosis, petiolis, petiolulis rhachideque inflorescentiarum minute puberulis et parce lepidotis; foliis vix discoloribus ternatis conjugatisve cirrho simplici clausis, breviter petiolatis, juveniis subtus molliter pubescentibus; petiolo valido, supra canaliculato; petiolulis petiolo brevioribus supra anguste canaliculatis; laminis oblongis, interdum ovato-oblongis, basi rotundatis, utrinque insigniter reticulato-venosis, supra nitidissimis atro-purpureis, costa prominula plus minusve pilosula, subtus opacis cupreo-purpureis, costa interdum pilosula venisque 6–7 primariis subprominentibus; panicula terminali, angusta, floribus pedicellatis, apice ramulorum congestis; bracteis bracteolisque parvis ovato-lanceolatis, acutis, minute pubescentibus; pedicellis modice longis; calyce tubuloso-campanulato, tomentoso, parte superiore distincte nigro-glanduloso denticulis 5 interdum glandulosis insidentibus; corolla tubuloso-campanulata, tubo basilari angusto apice abrupte expanso, lobulis late ovatis, basi constrictis apice obtusis, extus minutissime tomentella, intus minute puberula, circa insertionem staminum glanduloso-villosula, lobulis tomentellis; staminibus glabris, thecis divaricatis, staminodio apice capitellato; ovario glaberrimo, ovulis pro loculo circa 22, biseriatis; stigmatibus obtusis; capsula deest.

Petioli 0.7–1.2 cm. longi; petioluli 0.5–1 cm.; laminae 4.8 cm. longae, 1.5–3.2 cm. latae, Panicula 12 cm. longa. Pedicelli 2–3 mm. longi. Calyx 4–5 mm. longus. Corolla 1.4–1.8 cm. longa, lobulis 3–3.5 mm. longis, 2.7–3.5 mm. latis. Stamina circa 3 mm. supra basin corollae aequialte insidentia, majora 8 mm., minora circa 6 mm. longa; staminodium 3 mm. longum. Discus 0.8–1 mm. altus. Ovarium circa 2.5 mm. longum; stylus plus minusve 9 mm. longus.

LARA: Near El Tocuyo, flowers September 25, 1922. (*Dr. A. Jahn* 1186, type).

Closely allied to *A. Chica* Verlot, but differs in the minute indument of the stems, petioles and panicles, the distinct shape and size of the leaflets which

are but seldom entirely glabrous, in the dense short glandular pubescence of the insertion of the stamens and in the capitellate staminode and glabrous ovary.

9. **Arrabidaea guaricensis** Pittier, sp. nov.

Frutex deciduus, altissime scandens, basi crassus, ramis teretibus, striatis, glabris, cortice griseo hinc inde lenticellato tectis, ramulis novellis plus minusve tomentello-pubescentibus, pilis divaricatis; foliis subconcoloribus, membranaceis, ternatis conjugatisve, cirrho simplici clausis, longe petiolatis, petiolo tereto anguste canaliculato petiolulisque brevibus supra applanatis tomentoso-pubescentibus; laminis foliolorum late ovatis basi rotundatis subtruncatis subemarginatisve, apicem versus rotundatis et abrupte angusteque acuminatis, acumine fere mucronulato, supra opacis, minutissime reticulatis, costa venisque primariis 6–7 impressis minute pubescentibus, demum glaberrimis, subtus reticulatis, parce pubescentibus, costa venis venulisque prominentibus, marginibus ciliatis; cirrho gracili, pubescente, apice unguiculato; paniculis praecocibus, elongatis, angustis, terminalibus, pedunculis pedicellisque hirtello-pubescentibus; bracteis bracteolisque minutis, pubescentibus; calyce brevi, campanulato, extus pubescente, parcissime glanduloso, distincte 5-denticulato; corolla elongata, tubuloso-campanulata, lobulis late ovatis, obtusis, extus tubo basilari glabrato excepto dense pubescente, pilis retroflexis, intus insertionem, staminum pilis albis glandulosis interspersis vestita excepta, lobulisque glabra; staminibus glabris, thecis antherarum valde divaricatis; disco annulari, pulvinato, glabro; ovario apice minutissime hirtello-puberulo, utrinque lepidoto, ovulis biseriatis pro loculo 16–17; stylo glabro, stigmate acuto; capsula lineari, apice obtusa, plus minusve fulvo-pubescente; seminibus pro loculo 11–12.

Frutex basi 10 cm. crassus. Petioli 3–6 cm. longi; petioluli laterales 0.5 cm., terminales 1–5 cm. longi; laminae 5–12 cm. longae, 3.5–8 cm. latae. Panicula 15–30 cm. longa; bracteae et bracteolae plus minusve 0.5 cm. longae. Pedunculi et pedicelli 0.8–1 cm. longi. Calyx 4.5 mm. longus. Corolla 4–4.3 cm. longa, lobulis 1 cm. longis et latis. Stamina minora 0.9–1 cm., majora 1.3–1.4 cm. longa, subaequialte 6 mm. supra basin tubo corollae innixa; thecae antherarum circa 2 mm. longae. Discus 0.8–1 mm. altus. Ovarium 4 mm. longum; stylus 4–4.2 cm. longus. Capsula 14–17 cm. longa, 1.3 cm. lata, fulvescente; semina 0.9–1.1 cm. longa, 2.5–3 cm. lata.

GUÁRICO: Alrededores de Ortíz, in dry forests, flowers December 27, 1923 (*Pittier* 11308, type); same locality, fruits February 18, 1924 (*Pittier* 11432, type of the capsules); vicinity of El Sombrero, flowers and fruits February 19, 1924 (*Pittier* 11436).

This species occurs frequently in the deciduous forests along the tributaries of the Guárico river, between Ortíz and El Sombrero. It is a high climber, reaching the top of the tallest trees, where it spreads at flowering time like a brilliant crown of pale pink. Its affinities seem to be with *A. arthrerion* Bur., from which, however, it differs somewhat in most of its characters. The plant is distinctly deciduous and the bloom is always precocious.

10. **Arrabidaea ovalifolia** Pittier, sp. nov.

Frutex alte scandens, ramis glabris cortice griseo plus minusve lenticelloso tectis, ramulis virgatis petiolis petiolulis pedunculis pedicellisque puberulo-

pubescentibus; stipulis desunt; foliis ut videtur plerumque ternatis, ecirrhosis, longiuscule petiolatis, petiolis teretibus indistincte canaliculatis; foliolis petiolulatis, petioluli saepe longiusculis, supra vix applanatis, laminis ovalibus, basi rotundatis, lateralibus vix obliquis, apice rotundatis, anguste emarginatis, supra glaberrimis, reticulatis, costa venisque 5–6 prominulis, subtus in axillis venarum conspicue pilosulis, demum glaberrimis, laxe reticulatis, costa venisque subprominentibus; paniculis ex apice ramulorum axillarium auctis, elongatis; pedunculis longiusculis, dichotomis; pedicellis gracilibus; calyce campanulato, apice parce ciliato, 5-dentato (basi indistincte glanduloso, glandulis magnis?), extus dense lepidoto; corolla infundibuli-campanulata, extus minute furfuracea intus circa staminum insertionem, piloso-hispida, pilis canescentibus, demum parce furfuracea, tubo basin angustato, lobulis late ovatis apicem rotundatis; staminibus glabris, thecis divaricatis; disco crasso, glabro, pulvinato; ovario minutissime muricatulo, ovulis pro loculo 20, biseriatis; stylo glabro; capsula linearis, basi angustata, apicem mucronata, marginibus incrassatis; valvis applanatis, parce lepidotis, plus minusve impresso-punctatis; seminibus crassiusculis, alis hyalinis.

Petioli 3.5–7.5 cm. longi; petioluli 1.5–2.5 cm. longi; laminae 7–10 cm. longae, 4–6.5 cm. latae. Racemi usque ad 30 cm. longi; pedunculi I 2–4.5 cm., II 1–2 cm., pedicelli 0.8–1 cm. longi. Calyx 7–9 mm. longus. Corolla 4 cm. longa, lobulis 0.9–1 cm. longis, 0.9–1.1 latis. Stamina minora 0.9 cm., majora 1.3 cm. longa; staminodium 4 mm. longum. Discus 2 mm. altus. Ovarium 3 mm. longum; stylus 1.6 cm. longus. Capsula 27–33 cm. longa, 1.8 cm. lata; semina 1.5 cm. longa, 4 cm. lata.

ARAGUA: Banks of river near San Juan de los Morros, flowers and fruits April 9, 1927 (*Pittier* 12311, type, in Herb. Mus. Comm., Caracas, cotype in U. S. National Herbarium, Washington); between Parapara and Uberito, Guárico, fruits May 7, 1925 (*Pittier* 11799).

I have not been able to match this species with any described. It evidently should be placed very near *Bignonia glabrata* H.B.K. and *Arrabidaea rotundata* Bur. From the first it differs in having longer and pubescent petioles and petiolules, barbulate nerve axils and dull, distinctly emarginate leaflets (Kunth's diagnosis of *B. glabrata*, does not, however, extend to all important details and he did not see the flowers, which in our specimens were of a dark pink color). *Arrabidaea rotundata*, on the other hand, is described as having almost tomentose leaves, pubescent calyx, and a corolla tomentose without and papillose at the insertion of the stamens within; the capsules are shorter than in our specimens and slightly narrower; only the seeds do not seem to differ except in the greater width.

11. ARRABIDAEA MOLLISSIMA (H.B.K.) Bur. & K. Schum. in Mart. Fl. Bras. $8^2$: 46. 1896.

Valleys of Aragua (*Humboldt & Bonpland*, type).

12. ARRABIDAEA ROTUNDATA (H.B.K.) Bur. & K. Schum. in Mart. Fl. Bras. $8^2$: 48. 1896.

CARABOBO: Isla de las Aves, Valencia Lake (*Humboldt & Bonpland*, type).

13. ARRABIDAEA CARICHANENSIS (H.B.K.) Bur. & K. Schum. in Mart. Fl. Bras. $8^2$: 62. 1896.

BOLIVAR: Between Carichana and Encaramada, on the Orinoco margins (*Humboldt & Bonpland*, type).

14. **Arrabidaea Spraguei** Pittier, sp. nov.

Frutex alte scandens, ramis crassis longitudinaliter striatis minute parceque lenticellatis, ramulis teretibus minute pubescentibus mox glabris; foliis coriaceis, discoloribus, ternatis conjugatisve, petiolis validissimis teretibus petiolulisque 2–3-ve brevioribus superne canaliculatis, laminis basi truncatis, leviter emarginatis, vel juveniis in petiolum distincte breviterque attenuatis, apice obtusis vel saepe emarginatis, supra glabratis, in aetate sublucidis, reticulatis, costa venisque primariis circa 8 impressis, subtus in axillis barbatis, demum puberulis glabratisve, costa venisque prominentibus; cirrhis vulgo validissimis; paniculis axillaribus terminalibusque, rachi ramulisque minute pubescentibus, pedunculis pedicellisque divaricatis trichotomis; bracteis bracteolisque caducissimis vel subnullis; calyce campunulato, 5-nervato mucronatoque, plus minusve fissi-lobato, extus minutissime puberulo marginibus plus minusve ciliatis; corolla campanulato-infundibuliformi, purpureo-rosea, tubo basilari angusto, lobulis late ovatis, marginibus sinuatis, extus papilloso-puberula, intus insertionem staminum villoso-glandulosam excepta parce papillosa vel glabrata lobulis puberulis; staminibus glabris, inclusis, filamentis tenuibus, thecae valde divaricatis; staminodio elongato, apiculato; disco toruloso, laevi, glabro; ovario oblongo, minutissime lepidoto, ovulis pro loculo circa 15–16; stylo plus minusve pilosulo; stigmatibus puberulis, oblongis, apice obtusis; capsula lineari, basi apiceque cuneata, valvis coriaceis, extus rugulosis, glabris, nervo mediano tenui percursis; seminibus 12–14.

Petioli 2.5–4.2 cm.; petioluli 1.2–3.5 cm.; laminae 5.5–13 cm. longae, 3.5–9 cm. latae. Paniculae 10–35 cm. longae, 10–25 cm. latae; pedicelli 5–12 mm. longi. Calyx 0.9 cm. longus. Corolla 3.7–3.8 cm. longa, lobulis 1.1–1.2 cm. longis latisque. Filamenta 5 mm. supra tubi basilari basin inserta, 1–1.3 cm. longa; thecae 2.5–3 mm. longae; staminodium circa 4 mm. longum. Discus 1 mm. altus. Ovarium 2 mm. longum; stylus 1.5 cm. longus; stigma circa 2 mm. longum. Capsula 19–20 cm. longa, 1.7 cm. lata; semina 1.3 cm. longa, usque ad 4.5 cm. lata.

ARAGUA: San Juan de los Morros, in bushes, flowers February 22, 1924 (*Pittier* 11476, type).

GUÁRICO: Between Guarumen and Caimana bridges, road El Sombrero to Ortíz, flowers February 21, 1924 (*Pittier* 11469).

LARA: Banks of La Ruesga near Barquisimeto, flowers and fruits September 1923 (*J. Saer d'Héguert*, 1922).

The leaves of this species are distinctly paler underneath than above, hence there would be no mistake in placing it in subsection *Discolores*, near *A. tuberculata* and *A. subincana* P. DC. If, however, it should be assigned to the *Concolores*, its place should be with *A. rotundata* Bur. Its characters agree well enough with the description of *Bignonia balbisiana* P. DC., but not at all with that of *A. rotundata* Bur., as given in the *Flora Brasiliensis*.[2] It is more than likely that we really have here a new species, which we take pleasure in naming for Mr. T. A. Sprague, the learned authority on Bignoniaceae.

15. **Arrabidaea barquisimetensis** Pittier, sp. nov.

Frutex scandens, caule ramisque cortice griseo verruculoso tectis, ramulis annotinis et praecipue novellis hirtellis vel dense villosis; foliis ternatis

[2] 8[2]: 48. 1896.

conjugatisve cirrho crasso simplici apice valde incrassato interdum clausis, petiolis modice longis, gracilibus, teretibus, supra vix applanatis petiolulisque brevibus dense villosis; laminis ovatis, ovato-oblongis oblongo-ellipticisve, basi rotundatis plerumque complicatis apice sensim acutatis acuminatisve acumine nunc angusto et acuto, nunc lato obtusoque, supra nitentibus in sicco nigrescentibus, glabris, minute reticulatis, costa venisque impressis, subtus canescentibus primum dense villoso-tomentosis, in aetate glabrescentibus costa venisque 5–7 prominentibus villoso-hirtellis; paniculis terminalibus, brevibus, paucifloribus, pedicellis petiolulis multo longioribus pedunculoque brevi tomentoso-villosis; calyce campanulato, bilabiato, eglanduloso, extus parce villoso, lobulis subacutis; corolla infundibulari-campanulata, extus dense canescente furfuraceo-villosula, intus prope insertionem staminum glanduloso-villosula, lobulis villosulis, demum glaberrima, tubo basilari brevi, lobulis ovato-rotundatis, apice plus minusve denticulatis; staminibus glabris thecis valde divaricatis, connectivo vix prominente; staminodio subulato, apice vix incrassato; disco tubuloso, pulvinato, extus sulcato; ovario parce tuberculato, lepidoto, ovulis pro loculo 10–12, biseriatis, stylo glabro, stigmatis ovato-lanceolatis; capsula elongata, lata, basi cuneata, apice acutato-attenuata, glaberrima, seminibus pro loculo 6–8.

Petioli 1–5.5 cm. longi; petioluli 0.4–1.5 longi; laminae 4.5–11 cm. longae, 2–5.7 cm. latae. Paniculae 5–8 cm. longae. Pedicelli 0.8–1.5 cm. longi. Calyx circa 8 mm. longus, lobulis 2 mm. longis. Corolla 3.2 cm. longa, tubo basali 2.5–3 mm. longo, lobulis 0.7–1 cm. longis, 0.8 cm. latis. Filamenta 1.2–1.5 cm. long, 4 mm. supra basin corollae aequialte insidentia; thecae circa 3 mm. longae; staminodium 5 mm. longum. Discus circa 1.5 mm. altus. Ovarium 4 mm. longum; stylus circa 2 cm. longus. Capsula 27–31 cm. longa, 2 cm. lata; semina 1.6–1.7 cm. longa, circa 5.5 cm. lata.

LARA: La Ruesga near Barquisimeto, flowers and fruits May 1925 (*J. Saer d'Héguert* 214, type).

Open land species, growing in arid savannas and at times simply frutescent, and other times a climber. On account of its glandular and distinctly bilabiate calyx it may be questioned whether it really belongs in *Arrabidaea*. If so it may be placed in series *Indutae*, subseries *Discolores*, near *A. cinerea*, from which, besides in the already mentioned peculiarities of the calyx, it departs in the number of ovules, the shape of the disc and the indumentatum. Could it be identical with *A. mollissima* (H. B. K.) Bur. & K. Schum.?

16. ARRABIDAEA CALODYCTIOS Sprague, Bull. Misc. Inf. Kew 1927: 358. 1927.

FEDERAL DISTRICT: On the road from La Guaira to Caracas, 900 m., in thickets, flowers September 6, 1925 (*Pittier* 11883, type); same locality, flowers June 23, 1922 (*Pittier* 10377).

MÉRIDA: Lagunillas, 700 m., flowers April 3, 1922 (*Dr. A. Jahn* 1077).

17. **Arrabidaea lenticellosa** Pittier, sp. nov.

Frutex scandens, caulibus ramisque creberrime lenticellatis, glabris, ramulis modice crassis, subvirgatis, striatis, juveniis dense tomentellis, vestutioribus glabrescentibus; foliis leviter discoloribus ternatis conjugatisve cirrho simplici primum puberulo clausis, breviter petiolatis; petiolo canaliculato, plus minusve tomentello vel pubescente; foliolis modice petiolulatis, petiolulis

canaliculatis pubescentibus glabratisve, laminis ovalibus basi obtusis vel leviter emarginatis apice abrupte breviterque acuminatis acumine obtuso, supra costa venisque impressis, breviter villosulis exceptis glabris, subtus reticulatis, costa venis primariis 6–7 prominentibus venulisque prominulis parce pilosulis; inflorescentiis ad nodos supremos ramulorum defoliatorum panicullariformibus insertis; bracteis bracteolisque minutis, deciduis; pedunculis pedicellisque tenuibus villosulis; calyce membranaceo, violaceo, campanulato, insigniter 5-denticulato, lateraliter plus minusve fisso, extus praecipue basin cano-puberulo; corolla tubuloso-campanulata, tubo basilari angusto, lobulis magnis, ovato-oblongis, extus puberula, intus circa insertionem staminum villosa, lobulis puberulis; staminibus glabris apice corollae tubo basilari inserta, thecae valde divaricatis; staminodio filiformi, apice apiculato plus minusve spiraliter convoluto; disco cupulari, extus laevi; ovario minutissime denseque cano-lepidoto, ovulis pro loculo 18–24; stylo glabro, stigmatibus elongatis anguste lanceolato-apiculatis; capsular elongata, basi cuneata, apice longiuscule acuminata, marginibus incrassatis, valvis planis, glaberrimis nervo mediano prominulo percursis; seminibus pro loculo 18–24.

Caules ut videtur 4–6 m. longa, 2–3 cm. diam. Petioli 2–3 cm. longi; petioluli 1.2–1.5 cm. longi; laminae foliolorum 8–10 cm. longae, 5–6.5 cm. latae. Pedunculi I 5–7 cm., II 1–2 cm. longi; pedicelli 0.7–1 cm. longi. Calyx 0.8–1 cm. longus. Corolla 5.5 cm. longa, lobulis 1.3–2 cm. longis, 1.5 cm. latis. Filamenta 5–11 mm. longa; thecae circa 2.5 mm. longae. Discus 1.5 cm. altus. Pistillum circa 2.3 cm. longum; stigmata circiter 4 mm. longa. Capsula 20–33 cm. longa, 1.6–1.8 cm. lata; semina 1.3 cm. longa, 4–4.2 cm. lata.

GUÁRICO: Mesa of El Sombrero, in clusters of low bushes scattered over the savanna, flowers April 17, fruits and leaves September 10, 1927 (*Pittier* 12370, 12481, type).

This species has to be placed in subseries *Discolores* of the *Indutae*, near the Brazilian *A. tuberculata* and *A. subincana* P. DC. It is the first species reported from Venezuela of a group characterized by the peculiar pubescence of the leaves. The name refers to the appearance of the stems, densely covered with whitish lenticels.

18. ARRABIDAEA SIEBERI P. DC. Prodr. 9: 186. 1845.

FEDERAL DISTRICT: Hills above La Guaira (*Pittier* 9852).

MIRANDA: Cerros de los Mariches (*Pittier* 12449). GUÁRICO: Mesa de El Sombrero (*Pittier* 12494).

19. **Arrabidaea zuliaensis** Pittier, sp. nov.

Frutex alte scandens, ramis floriferis pendulosis, striatis, parce verruculosis minutissime puberulis; foliis coriaceis, basi ramulorum verosimiliter 3-foliolatis, superioribus 2-foliolatis cirrho simplici clausis; petiolis petiolulisque modice longis, canaliculatis, minutissime puberulis, laminis oblongo-ellipticis, basi rotundatis subcuneatisve saepe complicatis, apice sensim attenuatis, acuminatis, mucronulatis, supra opacis parcissime puberulis costa venisque circa 7 subprominentibus, subtus laxe reticulatis, minute velutinis, costa venisque prominentibus; paniculis amplis basi longe ramulosis, multifloribus, rhachi anguloso, pedunculis pedicellisque minute puberulis; floribus pedicellatis, in cymis umbelliformibus 3–8 dispositis, bracteis bracteolisque minutissimis,

caducis suffultis; calyce tubuloso apice versus sensim et leviter ampliato, truncato, edentulato, extus velutino-canescente; corolla violaceo-rosea vel purpurea, infundibulari-tubulosa, extus dense et minute, tomentello-puberula, intus prope staminum insertionem villosula lobulis tomentello-villosis, tubo basi angustissimo, calyce subduplo longiore, lobulis orbicularibus; staminibus glaberrimis, filamentis filiformibus, thecis valde divaricatis, arcuatis; staminodio filiformi, apice leviter expanso; disco tubuloso-annulari; ovario muricatulo; ovulis circiter 22 pro loculo, biseriatis; stylo glabro, stigmatibus ovatis, acutis; capsula deest.

Petioli 1.5–3.5 cm. longis, petioluli 1–1.5 cm.; laminae 5–12.5 cm. longae, 2–7 cm. latae. Pedunculi 0.5 mm., pedicelli 2–4 mm. longi. Calyx 4 mm. longus. Corolla 2.5 cm. longa, tubo basilari 7 mm. longo, lobulis 5 mm. longis et latis. Stamina circa 7 mm. supra basin corollae insidentia; filamenta 1.2–1.5 cm. longa; thecae circa 2 mm. longae. Discus 0.6 mm. altus. Ovarium 2 mm. longum; stylus circa 1.2 cm. longus.

ZULIA: Banks of Lora and Santa Ana rivers, in semihumid forests, flowers December 19, 1922 (*Pittier* 10992, type).

TRUJILLO: El Dividive, in savanna bushes, flowers November 28, 1922 (*Pittier* 10827).

*Arrabidaea zuliaensis* is a very near relative of *A. Schomburgkii* Klotzsch, of British Guiana, but it has larger flowers, a distinctive indumentatum leaves with more numerous primary veins, and the ovules in each cell constantly 22 instead of 18–20.

### 20. Arrabidaea cuprea Pittier, sp. nov.

Frutex sarmentosus, ramulis floriferis minutissime puberulis, striatis, foliis coriaceis, ternatis conjugatisve, cirrho simplici clausis, petiolis elongatis, angulosis striatisque, ecanaliculatis, petiolulisque canaliculatis plus minusve hirtellis, pilis crispulis; petiolulo terminale lateralibus 2–3-plo longiore; laminis ovalibus, basi rotundatis, apice breviter obtuso-acuminatis, mucronulatis, lateralibus valde obliquis semirotundatis semicuneatis, terminale basi rotundato supra plus minusve cupreo-coloratis, glaberrimis, minute reticulatis, costa venisque primariis circa 7 profunde impressis, subtus pallide viridibus, reticulatis, costa venis venulisque prominentissimis parce crispulo-hirtellis exceptis glaberrimis; paniculis terminalibus ramulosis, multifloribus, ramulis basilaribus ex axillis foliorum superiorum auctis, rhachide pedunculis pedicellisque brevibus minutissime furfuraceo-puberulis; bracteis bracteolisque parvis, ovatis, pariter pedicellis vestitis; calyce campanulato, apice truncato hinc inde denticulato, violaceo, extus plus minusve fulvescente puberulo; corolla infundibulari-tubulosa, tubo basilari brevi angusto, lobulis inaequalibus, late ovatis suborbicularibusve, extus minute furfuraceo-puberula, intus prope staminum insertionem villosula, lobulis puberulis, demum glabra; staminibus glabris, filamentis tenuibus; thecis divaricatis, connectivo vix conspicuo; staminodio filiformi, apice capitellato; disco cupulato, glabro, lateraliter sulcato; ovario utrinque lepidoto, ovulis pro loculo 18–20 biseriatis; stylo glabro, stigmatibus lanceolato-acutis.

Petioli 5–8.5 cm. longi; petiolulus terminalis 1.7–2.5 cm. longus; petioluli laterales 0.4–1 cm. longi; laminae 8–12 cm. longae, 4.5–7.5 cm. latae. Pedunculi 0.5–1.2 cm., pedicelli 1–2 mm. longi. Calyx 4–5 mm. longus. Corolla 2.2–2.4 cm. longa, tubo basilari 4 mm. longo, lobulis 5–7 mm. longis, 6–8

mm. latis. Stamina circa 4 mm. supra basin corollae insidentia; filamenta 9–13 mm. longa; thecae 2.8 mm. longae. Discus 0.8–1 mm. altus. Ovarium 2.3 mm. longum, stylus 12–13 mm. longus.

MIRANDA: Vicinity of Petare in low bushes in savannas, flowers September 11, 1927 (*Pittier* 9791, type).

Distinguished from the other species of the *Discolores* group by its glabrous leaves tinged above with purplish-red, the veins all deeply impressed, and covered with curly hairs on the opposite face. The thecae of the anthers show on their anterior side diminutive scars which correspond to the line of dehiscence.

# PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

## THE ACADEMY

### 216TH MEETING

The 216th meeting, a joint meeting with the Geological Society, was held on Wednesday, December 7, 1927, in the Assembly Hall of the Cosmos Club.

*Program:* Captain N. E. ODELL, F.G.S., of Toronto, *Scientific aspects of the Mount Everest Expeditions.* The three Expeditions to Mount Everest—of 1921, 1922, and 1924—though having primarily for their object the attainment of the summit of the world's highest mountain, have nevertheless yielded important scientific data from a region previously unexplored by white men. The results obtained relate to physiology, zoology, botany, geology, glaciology, as well as, in a more limited degree to meteorology and ethnography. In addition, an area of Southern Tibet amounting to more than 10,000 square miles was surveyed topographically, and upwards of 8000 square miles was mapped geologically.

Although the expeditions were at the outset equipped, as recommended by physiologists, with an apparatus providing oxygen for the high climbing parties, yet on the third expedition it was definitely ascertained that such a degree of natural acclimatisation can be attained that it would appear possible to achieve the summit of the mountain (trigonometrically determined first in 1849, and later found to be approximately 29,141 feet in altitude) without the aid of an artificial supply of oxygen. An elevation greater than 28,000 feet was reached entirely without its use.

New and interesting species of insects were discovered; bees, moths, and butterflies were found at 21,000 feet, and attid spiders occurred living in an environment solely of rocks and ice at 22,000 feet, while the alpine chough was seen manoeuvring easily and gracefully at 27,000 feet.

Lichens have been found to grow at higher Arctic latitudes, as well as at higher altitudes, than any other plants, but *Arenaria muscosa* was collected at 20,400 ft., and the common alpine edelweiss at 17,500 feet in the Everest region. However in 1905 *Delphinium glaciale* had been found at 20,600 feet on Kangchenjunga by Dr. Jules Jacot Guillarmod.

The southern portion of Tibet traversed consists predominantly of Mesozoic rocks, principally Jurassic shales and quartzites but moderately folded. The southern border of these are steeply upturned, together with a limited calcareous series in a subjacent position, against the gneisses of the main

Himalayan axis. The above calcareous series is of probable Permo-Trias age, at least in part, and would appear to compose as highly metamorphosed outliers the upper part of Everest itself and the neighboring mountains. Below this calcareous facies occur extensive biotite gneisses, which in turn rest on other calcareous metamorphics, of doubtful, though possibly Palaeozoic, age. The whole formation has been intruded by extensive granite-pegmatite veins and sills. There is evidence that a good deal of horizontal thrust has taken place, but the last movements in this region have been predominantly radial or vertical. The incoming of the Himalayan ortho-gneiss, found deep down in the range, has been accompanied by the uplift of the superimposed para-gneisses, which now form in many localities immense fault-scarp features overlooking the younger sediments of the Tibetan Plateau. The latter are cut locally by granitic and dioritic differentiation phases of the ortho-gneiss, and also by basic dyke-rocks of younger age.

There is evidence on all hands in the Mount Everest massif of waning glaciation. Old morainic terraces are to be seen bordering the valleys, and these extend far out on the plains to the north. Moreover there is evidence that during the maximum phase of the glacial cycle the ice mass accumulated in the area between the Great Himalayan Range and the Trans-Himalayan Ranges was sufficient to reverse the present direction of drainage and to have its outflow over many of the lower passes on to the southern slopes of the Great Range. This condition, especially during the wane of the maximum stage, would have a decided effect upon the trend of the subsequent of drainage of the region, and be a contributing cause no doubt to the astounding course taken by the Arun River in its upper reaches of the Yaru Chu.

On account of the unique combination of physical conditions of this region the existing glaciers hold many unusual features and structures. Of particular interest was a significant developement of the "vein structure" in part of the East Rongbuk Glacier. This phenomenon here gave rise to a remarkable feature called the "Trough," extending for more than 3 miles longitudinally down the glacier. Another interesting feature was the immense ice-pinnacles, often as much as 100 feet in height.

On the first expedition it was definitely ascertained that the Tibetan name for Mt. Everest is "Chomolungma," signifying "Goddess Mother of the Mountain Snows." This poetic name will in future be applied to the whole group, Mount Everest (named after Sir George Everest of the Indian Trigonometrical Survey, during whose regime the mountain was first measured) being retained for the highest point of the group. (*Author's abstract.*)

## 217TH MEETING

The 217th meeting, the 30th Annual Meeting, was held in the lecture room of the Carnegie Institution Building at 16th and P Sts., on Tuesday, January 10, 1928. The meeting was called to order at 8:15 P.M. by Vice-President AULT. The retiring President, ALEXANDER WETMORE, delivered an illustrated address entitled *Prehistoric Ornithology in North America.* (This JOURNAL **18**: 145–157. 1928.)

At the conclusion of the address there was a brief intermission, after which President WETMORE took the chair and called the annual business meeting to order. The minutes of the 29th annual meeting, held January 11, 1927, were read by the Recording Secretary and approved.

The report of the Corresponding Secretary, L. B. TUCKERMAN, was pre-

sented. He reported the election of F. A. VENING MEINESZ to honorary membership and the death of the following members: LÉON PIERRE MANOUVRIER, Honorary Member, CHARLES D. WALCOTT, Past President, WILLIAM H. DALL, CARL H. EIGENMANN, JAMES F. KEMP, CHARLES G. NUTTING, FREDERICK B. POWER, IRA REMSEN, CHARLES S. SARGENT, ERWIN F. SMITH, GEORGE B. SUDWORTH, ISRAEL C. WHITE, MILTON WHITNEY, WILLIAM P. WILSON.

On January 1, 1928, the membership consisted of 15 honorary members, three patrons, and 576 members, one of whom was a life member. The total membership was 594, of whom 384 reside in or near the District of Columbia, 178 in other parts of the continental United States, and 32 in foreign countries.

The Board of Managers held five meetings which were devoted mainly to routine business. The average attendance was thirteen members.

During the year the Washington Post of the Society of American Military Engineers was added to the societies affiliated with the ACADEMY. There are now eighteen affiliated societies.

The report of the Corresponding Secretary was ordered accepted.

The report of the Recording Secretary was presented by him. It showed that during 1927, in addition to the annual meeting, five meetings had been held, all in connection with affiliated societies. The subjects of the addresses at these meetings and the names of the speakers were given. The report was ordered accepted.

The report of the Treasurer, R. L. FARIS, was presented by him. Among other items of interest it showed the following: Total receipts during 1927, $5,936.33; Total disbursements, 1927, $5,205.65; Cash on hand, January 1, 1928, $2,939.41; Value of Academy's investments, $17,536.37; Estimated net worth, $19,884.74.

The report of the Auditing Committee, PAUL BARTSCH, Chairman, S. F. BLAKE and H. C. FULLER, was presented by the Chairman. The Committee found the Treasurer's report and records to be correct in every detail. The reports of the Treasurer and of the Auditing Committee were ordered accepted.

The report of the Board of Editors was presented by W. J. PETERS. The seventeenth annual volume of the Journal contained 564 pages and 72 principal articles, the distribution of which in various fields of science was indicated. The average cost per page was $6.53. In accordance with the recommendation of the Editors approved by the Board of Managers, no charge to authors was made for illustrations. The report of the Editors was ordered accepted.

The report of the Committee of Tellers, consisting of L. B. TUCKERMAN, Chairman, L. V. JUDSON and H. E. MERWIN, was presented by the Chairman. In accordance with the report the following were declared elected: *President*, R. B. SOSMAN; *Corresponding Secretary*, L. B. TUCKERMAN; *Recording Secretary*, W. D. LAMBERT; *Treasurer*, R. L. FARIS; *Non-resident Vice-Presidents*, B. W. EVERMANN, J. G. LIPMAN; *Managers*, WILLIAM BOWIE, F. E. WRIGHT.

The newly elected President was escorted to the Chair by Vice-President AULT. After taking the chair he announced the appointment of E. W. WOOLARD as Editor and of L. H. ADAMS as Chairman of the Committee on Membership.

The Corresponding Secretary reported that the following members of the Academy had been nominated for Vice-Presidents by the affiliated societies: WALTER HOUGH, *Archaeological;* E. A. GOLDMAN, *Biological;* G. W. MOREY, *Chemical;* A. G. BÖVING, *Entomological;* PAUL G. REDINGTON, *Foresters;*

E. V. COVILLE, *Geographic;* BENJAMIN SCHWARTZ, *Helminthological;* ALLEN C. CLARK, *Historical;* H. L. WHITTEMORE, *Mechanical Engineers;* P. R. HEYL, *Philosophical.*

The members so nominated were unanimously elected Vice Presidents.

No new business being presented, at 9.40 P.M. the meeting adjourned.

WALTER D. LAMBERT, *Recording Secretary.*

## THE GEOLOGICAL SOCIETY

### 439TH MEETING

The 439th meeting was held at the Cosmos Club, March 28, 1928, President HEWETT presiding.

*Informal communication:* C. S. Ross presented evidence that the St. Francis dam near Los Angeles, California, failed because the foundation rocks were weak. Investigations have shown that the part of the dam which failed rested on a pebbly clay known as "red conglomerate" and the part which remained standing rested on schist. Mr. Ross' microscopic examinations indicate that a band of clay two feet thick between the pebbly clay and the schist may be fault gouge. The failure of this weak clay (perhaps further weakened by water leakage along a fault) probably started the undermining of the dam. Discussed by Messrs. HOOTS and SEARS.

*Program:* C. W. WASHBURNE, New York City: *The origin of normal faults.* Which is the more active side of a normal fault? Equal activity of both walls is impossible if the resulting regional tilt toward the direction of upthrow results from curvature of the fault-surface. Tilt of this prevailing type requires that the fault-surface be concave toward the more active side, toward the downthrow of gravity faults and toward the upthrow of upthrust normal faults. That the rotation of blocks occurred generally against curved surfaces is deduced from the indications that the action was one of rather high rigidity, the associated bending of the rock being in most cases wholly inadequate to permit the observed tilt to occur against a plane surface of fracture. Systematic curvature thus becomes a logical requirement, but it is difficult to detect because generally the curve is too gentle, having a radius of many miles.

Faults of short radius of tilt, especially if the angle of tilt be high, should have the sharpest curvature. Such are the faults across the Elk Basin anticline, Wyoming. Here the close spacing of oil-wells permits the determination of the curvature of a few faults, all concave in section toward the upthrown side.

Study of the tilt and form of simple lone normal faults, so fully isolated from other coeval structures that the stresses making the latter did not interfere with those making the faults, leads to the conclusion that nearly all their activity lay on the upthrow sides. Examples are the Sierra Nevada; the fault-line of the main Mexican oil fields running from Dos Bocas through Huasteca, Naranjos, Cerro Azul and El Alamo; also the Kurrajong fault, west of Sydney, Australia; the Jackson Fault, Alabama, etc. Definite examples of gravity faults are unknown to the writer, except a few small examples that are better regarded as superficial land-slide settling.

The driving upward of a foot-wall could arise from the upbending of compressive shears. In fact it would increase the regional compression, if the radius of curvature of the fault be greater than the width of the tilted block.

On the other hand the gravitative subsidence of hanging walls could occur only under regional tension, and would make nearly vertical striae. Regional tension would create breccia along countless steep fissures wherever the hanging wall could not subside, which would occur more commonly than would the ability to subside. Brecciated fissures should be more common than normal faults, instead of being comparatively rare. Tension would create types of intersection of rock joints, such as dropped wedges, which the writer cannot find among the joints exposed in faulted regions, nor elsewhere. Rock is too weak to transmit effective tension, in fact one joint across a line of tension would suffice to nullify its power beyond that joint. Except as a weak superficial and local phenomenon, there is probably no tension in the earth's crust.

There seems to be ground for questioning the existence of tension even on the upper surface of growing anticlines. No evidence of it can be seen in the folded Pleistocene sea-beaches of New Zealand, nor in anticlines of the Columbia River basalt, which probably had little cover when folded. No breaks are visible over the tops of these folds, and none are present on the steep limbs of many of them but where faults occur on the limbs they fail to satisfy the probable effects of tension and permit a better interpretation. In these anticlines apparently each layer crept over the underlying layer far enough up the limbs to prevent any visible cracking of the top of the arch, as would have happened had their bending been like that of a rigid beam. Other anticlines, however, may be found whose outer surfaces display tension.

In a region subject to compression in one direction there could be no tension in another direction, because joints inclined at various angles to the main line of compression would transfer some of the pressure laterally, as would also any weak masses that could be mashed or squeezed. The intimate association of normal faults with many anticlines, with which they grew concomitantly, the inclination of their striae, the associated bending of the rock, and other phenomena, indicate that many normal faults were formed when the rock was under compression in all directions. General considerations make it probable that most normal faults were formed under compression.

A foot-wall under compression could not rise slowly without lifting the hanging wall with it. The motion must have been so rapid that the momentum of the active foot-wall made it slip upward beneath the relatively inactive hanging wall, which was held by inertia, or which more likely had a relatively small elastic rebound downward, equal movement being improbable because a subsiding hanging wall would have to displace a continuous solid mass below it, while the rising foot-wall need only lift the weight of overlying rock.

The velocity required to bring into play the elements of momentum and inertia is unknown, but according to Harry Fielding Reid, in a personal communication, it is much less than the writer had thought. Velocities of 10 feet per second probably will suffice to create these effects. The slip during a single earthquake may amount to 20 and possibly to 50 feet, but the seismograms suggest that these slips occur in two or more stages, so that each slip amounts to only a few feet. Microscopic study of a few slickensides indicates that the heat generated did not melt quartz, but theoretically it must have been appreciable.

Great significance is attached to faults intimately associated with anticlines. There are: (1) faults nearly normal (60° to 90°) to the anticlinal axes; and (2) faults parallel to the axes. (1) The cross-faults of anticlines run

nearly parallel to the line of greatest stress that made the anticline and are thought to have originated as *blätter* from the shear created by local difference in the horizontal stress. A break would dip away from the side receiving the more intense stress and moreover the foot-wall side presented greater area across the line of main stress. This made it thicken and rise more than the hanging wall side, which rose less. The striae now remaining on these faults are nearly vertical at their points of maximum throw high on the anticline but have low inclination where the faults die out, low on the two limbs. That the growth of the faults was at least slightly aided by pressure also at right angles to this, or along the axis, is indicated by the fact that the faults at Elk Basin, Wyo., that have observable curvature are concave in section toward the upthrown sides. At Elk Basin the cross-faults upthrown on their northwest sides are older, smaller and less numerous than those upthrown on the southeast. The comparatively rare first type of normal fault is formed during the main stages of folding, while the more common second type, mentioned below, appears to form during its last stages and to continue into stages wherein the rock-bending can hardly be detected. (2) Faults parallel to the axis of anticlines are especially characteristic of the steeper limb of asymmetric folds, where they invariably help to uplift the structure, pointing to the common origin of fault and fold. Such structures are called "fault-folds." In many cases, as at Casper Mountain, Wyoming, they are steep reversed faults near their termini, but are normal faults along the central parts of their courses, judging usually from the inclination of the main joints and minor slips which are there visible. Because of talus the inclination of the main fault rarely is determinable at such places, but at Mexia, Texas, an incipient or very small fault-fold is characterized by normal (N. W.) dip of the fault along the higher part of the structure and by reversed (S. E.) dip along the low southern part of the structure. In fault-folds the greatest displacement occurs in front of the highest part of the structure where both axis and fault generally have a small bend or bulge toward the "downthrown" area. Sharp "capes" and similar projections toward the "downthrown" area generally result from irregularities in the original fault fracture, rather than from later cross-faults. This class of faults generally has steep striae.

The second class of faults is thought to be analogous to the prevailing type of normal fault, which is thought to break nearly at right angles to the direction of main stress. Such breaks parallel to the main lines of folding characterize the great faulted regions of the earth, such as the late Tertiary faults of western North America. Horizontal motion along them, as along the San Andreas rift, California, arises probably from a later shift in the direction of stress.

The intersection of little faults in several regions, most thoroughly studied at Elk Basin, Wyo., and in several parts of New Zealand, shows a persistent relation in the relative age of parallel faults of opposite dip, those dipping one way being invariably older than those dipping the other way. It shows also a persistent relation in the relative age of faults of different trend. In other words there was no movement of "blocks" between little parallel faults of opposite dip, leading to the presumption that such movement probably did not occur in the large "blocks" within which many of the small observations were made. The same relation seems to hold between faults of different trend, except where those of one trend have low striae. Certainly many thrust-faults terminate in cross-faults with nearly horizontal striae, and isolated normal faults that can be followed to their termini bend strongly

toward the direction of upthrow. Where a fault is not isolated, its course will be affected by the concomitant strain of neighboring coeval breaks, as in a group of *en echelon* faults, each of which trend with typical concavity toward the upthrow, except at one end where with relatively small displacement it bends the other way to connect with the next *en echelon* fault. This relation is reported personally by Leon Pepperburg to hold for at least some members of the Mexia zone of faults. On the other hand the course of normal faults seems rarely to be affected by older breaks, which they cross at sharp angles without visible deviation. The course of the new break is more often affected by an old line of weakness nearly at right angles to it, which may make a sharp "cape" in the scarp, but usually a new fault cuts nearly straight across all older breaks, as though they did not exist.

These age relations between normal faults are readily explainable under the hypothesis that they arose from compressive shear, but not under the tensional theory, because there is no conceivable cause of systematic pull across a region in one direction during the first period of faulting, in the opposite direction during the next period, and in another opposing pair of directions during the next two periods of faulting. This is the problem presented for solution by the intersection of little faults at Elk Basin, Wyo., in various parts of New Zealand, and probably at other places where studies are less complete. It is explicable if we assume that the main stress across the area was exerted first in one direction and later in another, and that each of the two periods be divided in two parts, in the first of which the greater yielding to compression occurred to one side of the district in question, and in the second part of which the greater yielding occurred on the other side. Each period of faulting was too long to let us explain this alternation of stress through the operation of elastic rebound or other yielding to elastic stress. The elastic relief of compression, thought by some to create tensional faults, would tend merely to maintain compression.

Displacement is thought to arise generally from movements widely distributed through the rock, largely in its softer and more yielding parts, and originally inclined at low angles, but bending upward toward faults. Local thickening and bending of the more yielding rocks is thought to make an incipient fault-fold at right angles to the line of principal stress, the growth of which cracked the harder layers. Such a crack is thought to concentrate the movements distributed in the more yielding rock, the distributed movements bending gently upward toward the break that relieves them, and so feeding displacement to the fault. The distributed movements in the more yielding rock may be minute over-thrusts or pseudo-flowage. Where they have been most concentrated either through greater intensity or through longer application, the displacement is greatest, as viewed either in plan or in cross-section. Thus the systematic cross-faults of Elk Basin and other Wyoming anticlines seem to gather their displacement within the Cretaceous shales. The distributed movements that feed displacement to the trunk-fault may be regarded as its roots. Where the reverse action occurs, in the parts of a fault that lose displacement upward, even where part of the loss goes into monoclinal bending and where there are no visible branches, the phenomena correspond, except that they are reversed, displacement there being scattered into disseminated movements, instead of being gathered from the former.

The concentration of the disseminated movements in space would in itself cause their concentration in time, or greater velocity, but the high velocity of slipping is due mainly to the operation of elastic rebound, as explained by Harry Fielding Reid. The disseminated movements press with increasing

force against a line of fracture until the accumulated force exceeds the resistance, when a slip occurs. At that moment the rock is bent and compressed elastically and the relief of this condition is a sudden fling forward along the fault. The possible velocities are much higher than those required to create effects of momentum.

Under this theory, normal faults not only gather their displacement largely below, but they also start at depth and crack their way upward. On the other hand, under the theory of gravity faults, the force is applied from above, where the faults originate, cracking their way downward. Definite test of the two theories can be found in the character of the offsets of little faults wherever a district can be found in which there has been a second reversal of stress back to its original direction. So far the writer has been unable to find such a place, but some field doubtless will furnish the required proof.

These opinions arise from studies in broad sheets of sedimentary rock. Many of them do not apply to areas of igneous activity, although the broader principles probably hold true. (*Author's abstract.*)

Discussed by Messrs. SEARS, CAPPS, GILLULY, HESS, FERGUSON, LOVERING, BASS, BOWIE, HEWETT, GREIG, and RUBEY.

### 440TH MEETING

The 440th meeting was held at the Cosmos Club, April 11, 1928, President HEWETT presiding.

*Informal communication:* DAVID WHITE exhibited two small vertebrate fossils, a salamander and a fish, collected at Mazon Creek in the northeastern part of the Illinois coal field. The fossils are in ironstone nodules from rocks equivalent to the Allegheny (Pennsylvanian) formation. The Mazon Creek locality is noted for the fossil plants that have been collected there.

*Program:* Dr. CHRISTIAN POULSEN, Mineralogical Museum, Copenhagen: *The Danian formation.* The Danian formation consists almost exclusively of organic sediments which form a series of strata 30–40 feet thick. Three different main facies are found: Bryozoan limestone, Coccolite limestone and Coral limestone. The Bryozoan and Coccolite limestones are widely distributed in Denmark and found both in the lower and upper Danian, whereas the third important type of rock, the Coral limestone, is confined to the upper Danian and known only from a few localities, where the conditions were favorable to these animals.

The lower Bryozoan limestone and the base of the Danian outcrop in the famous Stevns Cliff section: This section shows the white chalk of the *Belemnitella mucronata* zone the uppermost part of which contains a little terrigenous material and numerous Bryozoa; the chalk is overlain by a thin layer of clay, the so-called Fish clay, which forms basins in the surface of the White chalk. Then follows a layer of limestone 2–3 feet thick, the Cyclaster limestone, which is overlain unconformably by the Bryzoan limestone.

Dr. A. ROSENKRANTZ,[1] who has recently studied the Stevns Cliff section and especially the strata between the White chalk and the Bryzoan limestone, outlines the geological history as follows: At the end of Senonian time the sea bottom on which the White chalk had been deposited was elevated to about sea-level. It is uncertain whether the basins in which the Fish clay was deposited existed at that time or were formed by erosion after emergence of the Senonian strata. Following this emergence the Fish clay was deposited.

[1] Meddelelser fra Dansk geologisk Forening 6. 1924.

Gradually the waters became clearer, resulting in a transition from the Fish clay to the pure Cyclaster limestone. This limestone was probably formed by material derived from the White chalk. After the deposition of the Cyclaster limestone the sea bottom rose above sea level. Erosion then leveled the land surface, leaving some of the Cyclaster limestone in the Fish clay basins. Weathering of the very flat and presumably low land hardened the surface layers so that the Cyclaster limestone as well as the White chalk in the spaces between the Fish clay basins was considerably hardened. At the same time the numerous sponges found in these sediments were decomposed, leaving more or less dendritic holes in the surface. After this land period the Danian sea swept in and covered the area. The holes in the sediments beneath were filled with Bryozoan limestone and thus Senonian and Danian species are found apparently in the same bed, as, macroscopically, there is not much difference between the limestone varieties in question.

The contact line between the Cyclaster limestone and the Bryozoan limestone is the lower limit of the Danian formation.

The fauna of the Bryozoan limestone is not greatly different from that of the Coccolite limestone, except for the presence of the Bryozoa. The only facies that shows essential faunal differences is the Coral limestone at Faxe. The Coral limestone at this famous locality contains, in addition to species known from the other facies, a very rich fauna of corals, lamellibranchs, gastropods, cephalopods and crustaceans. The corals are closely related to the forms now living on the bottom of the rather deep sea west of northern Norway.

Lithologically the Coccolite limestone shows a striking resemblance to the White chalk, but its fauna has the normal Danian aspect.

It is possible to divide the Danian into two subdivisions which, however, differ little in fauna or lithology. In the upper Danian the fauna contains a few characteristic species which are unknown in the lower Danian, such as *Crania tuberculata* Nilsson, *Terebratula lens* Nilsson and *Ditrupa schlotheimi* Rosenkrantz.

Toward the end of the Danian the sea became shallower as shown by intraformational conglomerates at some localities.

The Danian is overlain by greensand and glauconitic marls containing a typical Paleocene fauna.

Originally the Danian was regarded as the youngest subdivision of the Cretaceous system, but now several Danish geologists accept the opinion of De Grossouvre, that this formation should be considered the lowermost Tertiary. The position of the Danian, however, is still a matter of discussion. The fact that ammonites are not found above the Cyclaster limestone ought to be taken in consideration. On the other hand, the Danian fauna contains a very great number of persistent Senonian species, whereas only a few Danian species are found in the lowermost Paleocene; in other words the break beneath the Danian represents only a relatively short space of time, whereas the upper break must have been of long duration. These last mentioned facts are strong evidence that the Danian is the youngest subdivision of the Cretaceous system.

Typical Danian, or formations which can be correlated with it, are probably not to be found outside Scandinavia, perhaps with the exception of the Calcaire à Lithothamnium at Vigny, France, which contains *Hercoglossa danica* (Schlotheim), and *Nautilus Bellerophon* Lundgren; in addition to these species a certain number of Montian species are found in the Vigny

fauna. E. Haug[2] therefore regarded the Calcaire à Lithothamnium as passage beds. The Calcaire à Lithothamnium probably corresponds to the lacuna above the Danian in Denmark as suggested by J. P. J. Ravn.[3] (*Author's abstract.*)

Discussed by Messrs. CAPPS, STANTON, SCHALLER, RESSER, GOLDMAN, and Miss GARDNER.

H. W. HOOTS: *The structural history and unusual rock types of the Santa Monica Mountains, southern California.* The Santa Monica Mountains are one of the prominent structural features which adjoin the Los Angeles Basin in southern California, one of the most prolific oil producing districts known. Even though the eastern part of the Santa Monica Mountains will themselves probably yield no oil, the importance to the petroleum industry of knowledge concerning the rock types and detailed geologic history of this area is apparent. The area contains many striking geologic features and, inasmuch as it adjoins a thickly populated educational center and is easily accessible by automobile, it provides an interesting field for the trained geologist and for student classes from the several universities of southern California.

The eastern part of the Santa Monica Mountains, east of Topanga Canyon, presents a section of varied rock types including coarsely crystalline plutonics, "basic" and "acidic" intrusives and pyroclastics, metamorphic strata consisting of slate and schist, and a wide assortment of sedimentary rocks. The stratigraphic record is far from complete; the presence of Paleozoic rocks is very doubtful and there is a gap in the early Tertiary record representing much of middle and late Eocene and Oligocene times. The Mesozoic appears to be fairly well represented although Jurassic deposits may not be present and the age of the Triassic (?) rocks is not established beyond dispute. Except for a fragmentary exposed Pliocene record and a gap representing an important but unknown thickness of middle Miocene rocks, the late Tertiary and Quaternary, beginning with lower Miocene, is fairly complete.

The accompanying table gives a list of the rock formations exposed in the eastern part of the Santa Monica Mountains and information regarding their probable ages and general characteristics.

Structurally, the eastern part of the Santa Monica Mountains is a broad open anticline, the axis of which lies in the extensive central area of Santa Monica slate and plunges westward from the major granitic intrusive mass just north of Hollywood. The attitudes of younger rocks, particularly those of Miocene age which cover so much of the north and south flanks of the mountains, conform in a general way to this anticlinal structure. It is apparent from the presence of several pronounced unconformities, however, that this major fold has experienced several stages of growth and deformation. The anticlinal structure is still clearly obvious in the central part of the district, but in the eastern and western parts the original fold has been so intricately deformed by block faulting and igneous intrusion that much of the fold is either difficult to recognize as such, or is down faulted and entirely concealed beneath alluvium. Pre-Modelo diastrophism produced an anticline which, judging from the westward plunge of the fold, was complete in the district east of Topanga Canyon, although similar major uplifts of this age no doubt occurred farther west; post-Modelo diastrophism, however, was responsible for anticlinal uplift which affected a larger area as a unit, an area which included the district west of Topanga Canyon as well.

[2] *Traité de Géologie* **2**: 1406. Paris, 1908–11.

[3] Danmarks geologiske Undersøgelse, 2 Række, No. 43, p. 40.

From the distribution of spotted slate and the known relation of this slate to the major exposed granitic intrusion, it is believed that much of the area along and north of the anticlinal axis is underlain by a much larger intrusive body of granitic rock. The broad open character of the fold, a unique structural feature for the Coast Ranges of California, is that which might be expected to result from bodily uplift by a large deep-seated intrusion. However, since most of the folding occurred during and since Miocene time, and since there are no known granitic rocks of Tertiary age on the west coast, it seems improbable that intrusion of granite has itself produced this fold. It does seem probable, however, that the character of the fold produced by late Tertiary uplift was controlled in some measure by the presence of a large, much older body of granitic rock beneath the folded area.

The structural features of this district are particularly striking. One is the post-Topanga (Middle Miocene), pre-Modelo (Upper Miocene) unconformity which represents the only period of folding (see table on pp. 354–355), which contests in importance that deformation which occurred near the close of the Pliocene. The other is the remarkably close association between faults and intrusions of basalt in the pre-Modelo rocks of the Topanga and Santa Ynez Canyon district, an association which forces the conclusion that faulting and intrusions of basalt had a close genetic relation during the period of post-Topanga, pre-Modelo diastrophism.

Several types of rock occur in this area which, judging from the literature, are not common in California. Some of them are known elsewhere but have not yet been described in detail. The spotted slate, a contact metamorphic facies of the Santa Monica slate, is worthy of additional study and is to be described in a paper now in preparation.

In the Martinez formation (lower Eocene), and possibly also in the Chico formation (Upper Cretaceous) of some areas, occur prominent reefs of white limestone from a few feet to 50–60 feet thick. These reefs commonly extend for not more than a few hundred feet and terminate in an abrupt wall; the largest reef is approximately 500 feet long. This limestone is distinctly nodular, has irregular bedding, and is characteristically spotted, due to the abundance of nearly white irregularly shaped algae and algal colonies imbedded in a limestone or argillaceous matrix of light brown or gray color. The algae are of the lithothamnion type but have not as yet been studied in detail.

The Modelo formation contains several rock types of unusual interest. A massive bed at the base, lying directly upon the Santa Monica slate, has a typical dark gray color due to the abundance of slate fragments. According to the terminology of some geologists this slate-fragment sandstone may be classified under the group name graywacke. Locally it is very fossiliferous; in other places it is absent and its stratigraphic position is occupied by a 4 to 6 inch bed of oolitic phosphate, another type of rock which does not appear to be common in the California Tertiary.

The siliceous shale of the Modelo is not in the least unusual for the Miocene of California but its siliceous character and association with beds of volcanic ash and bentonite, its micro-fossil content, and its remarkable banding provide ample material for a number of interesting speculations. (*Author's abstract.*)

Discussed by Messrs. HEWETT, RUBEY, BUTTS, and STANTON.

W. W. RUBEY, A. A. BAKER, *Secretaries.*

TABLE OF ROCK FORMATIONS AND UNCONFORMITIES IN SANTA MONICA MOUNTAINS, CALIFORNIA

| *Geologic age* | *Formation* | *Character and approximate thickness* | *Feet* |
|---|---|---|---|
| Recent | Alluvium | Breccia-conglomerate, sandstone, and silt. | 0–100± |
| Pleistocene | Alluvial plain now uplifted and deeply dissected | Poorly sorted reddish brown breccia-conglomerate and sandstone with earthy matrix and indistinct bedding. This alluvial plain, now far above present level of drainage, has been given the name Santa Monica Plain. | 0–300± |
| | Marine Pleistocene | Fossiliferous soft gray sandstone and sandy clay. | 5–50± |
| *Unconformity* (Horizontal Pleistocene rests directly upon Pliocene, dipping as much as 60°) | | | |
| Pliocene | Pico formation | Soft dark gray clay and sandstone with lenses and concretions of yellowish gray limestone. Exposed only in coastal belt northwest of Santa Monica. | 1,000± |
| *Unconformity* (Some folding and erosion but importance uncertain because of limited distribution of Pliocene) | | | |
| Miocene | | | |
| Upper Miocene | Modelo[a] formation | | |
| | Upper member | White punky diatomaceous and foraminiferal shale and fine sandstone grading laterally into clay-shale and sandstone. | 2,300± |
| | Lower member | Soft light gray to brown well-bedded shale, banded hard platy siliceous shale, thin and thick massive beds of sandstone and conglomeratic sandstone, and volcanic ash. Much of shale is foraminiferal. | 2,250± |
| *Unconformity* (Represents the most pronounced pre-Pliocene deformation, which, in this case included folding, faulting, and basalt intrusion) | | | |
| Middle Miocene | Topanga formation | Massive fossiliferous sandstone and conglomerate and thinly bedded shale and sandstone intercalated with intrusive and extrusive basalt and pyroclastics of lower and upper Topanga age. Basal 1,000 feet of conglomerate west of Cahuenga Avenue may be Vaqueros. | 4,500–7,500± |
| Lower Miocene and Oligocene(?) | Sespe(?)-Vaqueros(?) formation | Light gray and red conglomerate and conglomeratic sandstone. Unfossiliferous. | 3,500–4,000± |
| *Unconformity* (An important stratigraphic gap produced by some folding and erosion of uncertain magnitude) | | | |

| | | | |
|---|---|---|---|
| Eocene | | | |
| Lower Eocene | Martinez formation | Soft brown shale, sandy shale, and sandstone, with hard limestone concretions containing fossils. Prominent discontinuous reefs of white algal limestone are conspicuous. | 250+(?) |
| Cretaceous (Upper) | Chico formation | Massive brown and gray conglomerate and sandstone and dark gray shale. Fossiliferous. May also contain reefs of white algal limestone. | 8,000± |
| *Unconformity* (Not exposed, but unquestionably present because of striking difference in metamorphism of Cretaceous rocks and older slates, exposed contacts of which are faults) | | | |
| Jurassic(?) | Granitic intrusion | Granite and granodiorite. May be of Paleozoic age. | |
| Triassic(?) | Santa Monica slate | Black slate, much of which has undergone contact, as well as regional, metamorphism and is locally altered to mica schist. Base not exposed. | 5,000–7,000± |

[a] The rocks herein called the Modelo formation appear to be entirely of upper Miocene age and are not, therefore, the exact equivalent of the Modelo in the type district of the Santa Clara Valley which is believed by W.S.W. Kew to include rocks of both middle and upper Miocene age.

## SCIENTIFIC NOTES AND NEWS

Mr. H. W. Hoots has resigned from the U. S. Geological Survey to engage in petroleum engineering with the Union Oil Company, Los Angeles, California.

The offer of the Smithsonian Institute to take over and maintain the Mycological Collection of the late C. G. Lloyd of Cincinnati, which had been without a curator since the death of the founder in 1926, has been accepted by the trustees of the Lloyd Library and Museum; and the collection has been moved to Washington and is now in process of installation. This outstanding collection of the larger fungi, gathered together during the life time of Curtis Gates Lloyd, contains a number of specimens variously estimated at 50,000 to 100,000, nearly 10,000 negatives of fungus subjects, hundreds of photographic prints, half-tones of all the illustrations issued in Mr. Lloyd's numerous publications, voluminous correspondence with practically all the mycologists of the world active during his life time, many notebooks, and a great mass of manuscript records pertaining to the specimens. The collection will be maintained as a separate unit by the Office of Mycology and Disease Survey, in the Bureau of Plant Industry, under the immediate supervision of a custodian to be named by the Smithsonian Institution. It will be housed in steel herbarium cases and in a fire-proof building. The cataloging of the herbarium and the arranging and indexing of the other materials constituting the collection will be commenced shortly, and it is expected that this work will be completed within two years. The herbarium and supporting collections will then be available for the use of all interested mycological workers.